

First record of Paintedhand Mudbug (*Lacunicambarus polychromatus*) in Ontario and Canada and the significance of iNaturalist in making new discoveries

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Abstract

Paintedhand Mudbug (*Lacunicambarus polychromatus* (Thoma, Jezerinac & Simon 2005)) (Decapoda: Cambaridae) was recently discovered at three locations in Windsor, Ontario. These represent the first reports of this burrowing crayfish in Canada. iNaturalist, a nature app and website designed to record photo-based observations of plants and animals, was instrumental in facilitating this discovery. We discuss the importance of collaborative platforms, such as iNaturalist, for linking naturalists and citizen scientists to taxonomic experts around the globe.

Key words: Cambaridae; crayfish; Decapoda; iNaturalist; *Lacunicambarus polychromatus*; new distribution record; Ontario; Paintedhand Mudbug

Introduction

Paintedhand Mudbug (*Lacunicambarus polychromatus*) is a burrowing crayfish in the family Cambaridae that was newly described in 2005 (Thoma *et al.* 2005). Until recently, it was included in the genus *Cambarus* Erichson, 1846, in the rejected subgenus *Tubericambarus* Jezerinac, 1993 (Crandall and De Grave 2017). Phylogenetic analyses of mitochondrial DNA (mtDNA) sequence data combined with morphological and ecological characteristics have, however, indicated that *L. polychromatus* and several closely related species of burrowing crayfish are monophyletic and distinct from *Cambarus* (Glon *et al.* 2018). As a result, the subgenus *Lacunicambarus* Hobbs, 1969 has been resurrected and redescribed at the generic level to accommodate them (Glon *et al.* 2018).

Lacunicambarus polychromatus is known from throughout much of the North American midwest east of the Mississippi River (with the exception of a recent record from Missouri; Missouri Statewide Historical Crayfish Database 2019), as well as parts of Kentucky and Tennessee (see Figure 2 in Thoma

et al. 2005). Throughout its range, *L. polychromatus* is commonly found in burrows in low-lying habitats close to the water table, including the banks and floodplains of lakes and rivers, roadside ditches, and wetlands (Thoma *et al.* 2005). The recent recognition of *L. polychromatus*, stemming in part from historical confusion with the closely related Devil Crayfish (*Lacunicambarus diogenes*), has led to a relative paucity of correctly identified records of this species in museum collections and databases. The full extent of the range of *L. polychromatus*, therefore, remains undetermined, and no records of this species have been reported previously from Canada.

Methods

On 26 May 2017, members of the Committee on the Status of Species at Risk in Ontario (COSSARO) visited the Ojibway Prairie Provincial Nature Reserve (42.263°N, 83.071°W) in Windsor, Ontario, along with several staff from the Ontario Ministry of Natural Resources and Forestry and the Ojibway Nature Centre, City of Windsor. During the visit,

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a large adult burrowing crayfish was encountered above ground during the daytime. The individual was photographed and the photos (Figure 1) were uploaded to iNaturalist (see <https://inaturalist.ca/observations/6501788>), a web-based application designed to capture and share photo-based records of plants and animals. At the time of the observation, the crayfish was identified as *L. aff. diogenes* (see Glon *et al.* 2018), a species known to occur in Ontario, Canada (Crocker and Barr 1968; Guiasu *et al.* 1996; Hamr 1998). Six months later, the iNaturalist record was discovered by M.G.G., an expert on the taxonomy of *Lacunicambarus* currently working on revising the genus, who suspected that it was more likely to be *L. polychromatus*. Additional photos were uploaded to the record allowing for confirmation that the species was indeed *L. polychromatus*, a species not previously reported for Canada.

On 15 May 2018, C.D.J. and M.G.G. returned to the original location to conduct additional surveys for the species and to collect a voucher specimen and tissue samples for DNA analysis. Burrows were

searched for in ditches and along watercourses, and a hand-pumping technique, which included pouring additional water into the burrows, was used to bring the crayfish to the surface. Surveys for burrowing crayfish were also conducted on the same day at four additional locations in the Windsor area (Figure 2, Table 1). When burrows were located, the technique described above was used to extract crayfish. Voucher specimens were collected at each location where crayfish were found and have been deposited at the Royal Ontario Museum, Toronto, Ontario. A tissue sample was also taken from the Ojibway Prairie specimen for mtDNA sequencing.

Results

The surveys on 15 May 2018 at Ojibway Prairie Provincial Nature Reserve were successful in confirming the presence of *L. polychromatus*. At this location, burrows were found along a shallow ditch running along the northern edge of the nature reserve not far from where the specimen was located in 2017. The nature reserve is 105 ha in size and includes a



FIGURE 1. Paintedhand Mudbug (*Lacunicambarus polychromatus*) recorded on 26 May 2017 at Ojibway Prairie Provincial Nature Reserve, Windsor, Ontario. Distinguishing characteristics of the species are indicated by lines: closed areola (a, c); deflected rostrum (b1); suborbital angle (b2); dorsal surface of the palm of the chela with mesial quarter to third studded with tubercles not forming distinct rows (d). Photos: Colin D. Jones.

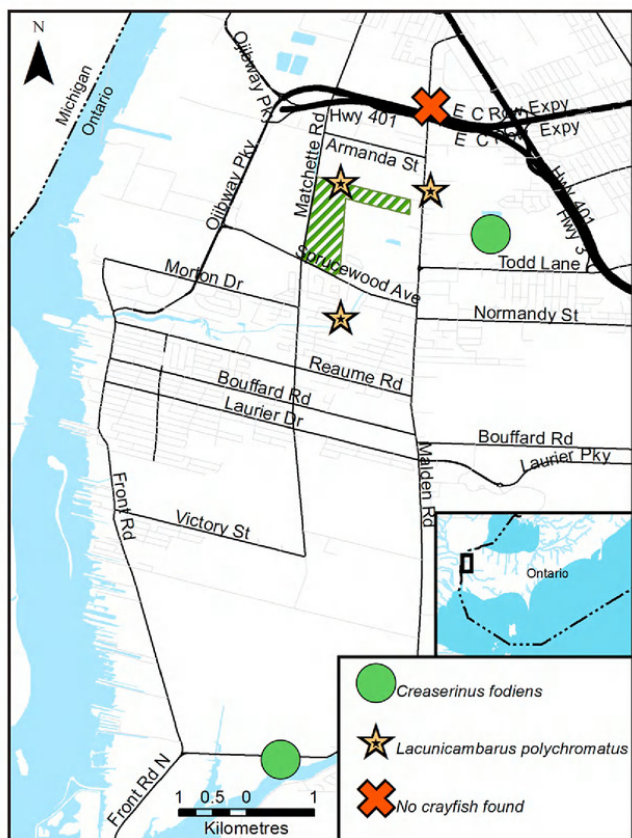


FIGURE 2. The six survey sites in the Windsor, Ontario, area. Stars indicate the three locations where Paintedhand Mudbug (*Lacunicambarus polychromatus*) was detected. Circles indicate the two locations where Digger Crayfish (*Creaserinus fodiens*) was found. The × indicates a location where no crayfish burrows or crayfish were found. The hatched area represents the Ojibway Prairie Provincial Nature Reserve.

combination of native tallgrass prairie and prairie/savanna habitat. It is part of a complex of closely situated natural areas located in the City of Windsor that together protect nearly 350 ha of native prairie, savanna, and forest.

A single specimen of *L. polychromatus* was collected, preserved in 95% ethanol and deposited at the Royal Ontario Museum (ROMIZ L5261). The GenBank accession numbers for 12S (MH878691), 16S (MH878723), and partial CO1 (MH882991) have been previously reported in Glon *et al.* (2019).

On the same day, *L. polychromatus* was also collected from a nearby site, Vince Marcotte Park (42.245°N, 83.071°W). Unlike the natural habitat of the nature reserve, the burrows at Vince Marcotte Park were located on the manicured lawn of the park bordering Turkey Creek. There were many burrows at this location and two specimens of *L. polychromatus* were collected and deposited at the Royal Ontario Museum (Table 1, Figure 2).

On 15 May 2018, three additional sites were surveyed (Table 1). At one site, no crayfish burrows were

located. At the other two sites, crayfish burrows were found and hand-pumped. The species present, however, was Digger Crayfish (*Creaserinus fodiens*), which was first discovered in Ontario, Canada, in 1863 and is often found living in burrows adjacent to those of *L. polychromatus* in the United States (Cottle 1863; Hobbs 1974).

Following the discovery that *L. polychromatus* occurs in the Windsor area (Table 1), an additional photo-based record was uploaded to iNaturalist from a third location adjacent to Ojibway Prairie. An individual was found by Steve Marks above ground, at night, and backdated to 24 May 2016 (see <https://inaturalist.ca/observations/17855665>). The location is a residential yard bordered by a shallow drainage ditch adjacent to a dry-moist old field. Crayfish burrows are periodically found in the manicured lawn and along the banks of the ditch at this location, but no attempts have been made to survey for crayfish.

Discussion

The Ojibway Prairie complex in extreme southwestern Ontario supports a number of plant and animal species that are restricted to this unique portion of the province, not to mention the entire country (Oldham 1992; Paiero *et al.* 2010; Pratt 2018). The discovery of *L. polychromatus* here represents the first record of the species in Canada. The closest known occurrences are in adjacent Michigan, where it has been known since it was first described (Thoma *et al.* 2005); thus, it is not entirely surprising that it was eventually recorded across the Detroit River in the Windsor area. *Lacunicambarus polychromatus* is almost certainly native to Canada, rather than being a recent colonizer or introduction, and its presence has likely gone undetected because of historical confusion about the taxonomy of *Lacunicambarus*. Additional surveys will be required throughout southwestern Ontario to delineate the full extent of the species' range in Canada. We also suggest that preserved specimens ascribed to "*C. diogenes*" (i.e., *L. aff. diogenes*) be re-examined, particularly if they were collected before *L. polychromatus* was described in 2005, to determine if the latter species is more widely distributed in Ontario than the observations documented herein led us to believe. Such information will also be critical in making an accurate assessment of the species' conservation status provincially and nationally.

Lacunicambarus polychromatus can be differentiated from all other Canadian crayfishes by its closed areola (Figure 1a,c); strongly deflected rostrum (in lateral view; Figure 1b1); presence of a suborbital angle (Figure 1b2); Form I male gonopods with two terminal elements directed caudally at approxi-

TABLE 1. Records of Paintedhand Mudbug (*Lacunicambarus polychromatus*) from Ontario, Canada, including locations where the species was searched for unsuccessfully. Repositories include both iNaturalist (for photo-based records) and the Royal Ontario Museum (ROM). Catalog numbers for iNaturalist refer to the unique record number and are accessible online by adding the catalog number to the end of the URL, <https://inaturalist.ca/observations/>.

Date	Location	Latitude, °N	Longitude, °W	Habitat	Details	Observers	Repository	Catalog no.
24 May 2016	Lambton St., Windsor	42.262	83.059	Suburban yard bordering drainage ditch	Incidental; one <i>L. polychromatus</i> photographed	S.M.	iNaturalist	17855665
26 May 2017	Ojibway Prairie Provincial Nature Reserve, Windsor	42.263	83.071	Native tallgrass prairie	Incidental; one <i>L. polychromatus</i> photographed	C.D.J., M.G.G., K.C., S.M.P., P.D.P., T.J.P., + COSSARO members	iNaturalist	6501788
15 May 2018	Ojibway Prairie Provincial Nature Reserve, Windsor	42.263	83.071	Shallow ditch bordering native tallgrass prairie	Targetted search; burrows detected and pumped; one <i>L. polychromatus</i> collected	M.G.G., C.D.J.	ROM iNaturalist	ROMIZ L5261 12590089
15 May 2018	Vince Marcotte Park, Windsor	42.245	83.071	Urban park lawn bordering creek	Targetted search; burrows detected and pumped; two <i>L. polychromatus</i> collected	M.G.G., C.D.J.	ROM	ROMIZ L5262 ROMIZ L5263
15 May 2018	Continental Ave., Windsor	42.273	83.059	Roadside ditch bordering small field in industrial area	Targetted search; no burrows or crayfish detected	M.G.G., C.D.J.	iNaturalist n/a	12590307 n/a
15 May 2018	Spring Garden Natural Area, Windsor	42.256	83.051	Wooded swamp	Targetted search; burrows detected and pumped; one <i>Creaserinus fodiens</i> (Digger Crayfish) collected	M.G.G., C.D.J.	ROM iNaturalist	ROMIZ L5265 12590235
15 May 2018	River Canard Park, Amherstburg	42.186	83.079	Roadside ditch bordering recreational park	Targetted search; burrows detected and pumped; one <i>Creaserinus fodiens</i> collected	M.G.G., C.D.J.	ROM iNaturalist	ROMIZ L5264 12590320

mately 90° relative to the gonopod shaft, the distal most of which (central projection) is markedly shorter than the proximal one (mesial process); and dorsal surface of the palm of the chela with mesial quarter to third studded with tubercles not forming distinct rows (Figure 1d). Although colouration is subject to variation and is not always a reliable character, *L. polychromatus* typically exhibits striking orange and red highlights along its rostral margins, chelae, and the dorsoposterior margins of its abdominal somites and blue or green shades across its body (Figure 1a–d). This crayfish is almost always collected from burrows, but it is occasionally encountered in open waters or even on land, particularly after heavy rain. Burrows with recent activity have fresh mud at the opening (Figure 3) often forming a chimney (Figure 4). The burrows themselves are not, however, diagnostic to species, and there are several species of burrowing crayfish.

iNaturalist was instrumental in facilitating the discovery of this species in Canada. Had it not been for iNaturalist, its presence may have remained undetected. As iNaturalist grows in popularity, more and more amateur naturalists and citizen scientists are uploading their photos and seeking confirmation of their identification. For example, in the 10 years since its inception in 2008 over 7 000 000 observations have been contributed by 224 334 users (iNaturalist 2019). In 2018 alone, the total number of observations more than doubled to well over 15 000 000 and the number of users also more than doubled to an astonishing 501 308 (iNaturalist 2019; also see Martin 2018 for a summary of Canadian records). At the same time, more and more taxonomic experts are becoming involved in iNaturalist by offering their expertise at providing or correcting identifications. This was certainly the case with the Ojibway Prairie record of *L. polychromatus* that would have been entered in field notes and potentially in databases as a record of *L. aff. diogenes*. In time, the photos may have been re-examined and re-determined as *L. polychromatus*, but iNaturalist has provided a platform that has greatly increased the ability of amateurs and experts to collaborate in real time. This collaboration is greatly increasing our collective knowledge of the distribution and, in fact, the conservation status of species.

There are other examples of this rapid increase in species discoveries. In Ontario alone, for example, at least 40 species of moths new to the province (at least 19 of which are new to Canada and one new to North America) have been discovered (M.V.B. Burrell pers. comm. 22 January 2019) through iNaturalist submissions since the recent publication of a comprehensive annotated Canadian Lepidoptera list (Pohl *et al.* 2018).

As species, such as Paintedhand Mudbug, are new-



FIGURE 3. Fresh mud at the opening of a crayfish burrow in Vince Marcotte Park, Windsor, Ontario, Canada (42.245°N, 83.071°W), 15 May 2018. Photo: Colin D. Jones.



FIGURE 4. A Paintedhand Mudbug (*Lacunicambarus polychromatus*) chimney in Muhlenberg County, Kentucky, USA (37.313°N, 87.201°W), 11 June 2018. Photo: Mael G. Glon.

ly discovered in Ontario, they are added to the provincial species list maintained by the Natural Heritage Information Centre (NHIC), Ontario Ministry of Natural Resources and Forestry, and are assigned a conservation status rank following methods developed by NatureServe (Faber-Langendoen *et al.* 2012; Master *et al.* 2012). Paintedhand Mudbug has been assigned a rank of S1S2 (critically imperilled to imperilled). The NHIC typically compiles observations of species with a conservation status rank of S3 (vulnerable) or higher. These observations then inform areas of conservation value (element occurrences) and are added to the provincial record where they are available to inform conservation, land-use, and natural resources management planning, policy, and legislation.

iNaturalist is also greatly increasing the ability to detect the introduction of exotic and potentially invasive species. A new and potentially invasive vascular plant species, Small-flowered Jewelweed (*Impatiens parviflora* de Candolle), for example, has been

recently documented in Ontario through iNaturalist (Oldham 2018).

The growth and popularity of iNaturalist is not showing any signs of slowing down. With such growth, an increasing number of local, regional, and national discoveries will be made, such as the discovery of *L. polychromatus* in Canada. Such discoveries will assist in advancing our collective knowledge of the distribution and conservation status of species. The NHIC has created a project on iNaturalist that users can join allowing their personal observations of provincially rare species to be considered for incorporation into the provincial record (<https://inaturalist.ca/projects/nhic-rare-species-of-ontario>).

Author Contributions

Writing – Original Draft: C.D.J. and M.G.G.; Writing – Review and Editing: all; Conceptualization – C.D.J. and M.G.G.; Methods – M.G.G. and C.D.J.; Investigation – all.

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